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Trueness and Precision of Conventional vs Digital Impressions in a Kennedy Class III Case

Kennedy Sınıf III Bir Olguda Konvansiyonel ve Dijital Ölçü Yöntemlerinin Doğruluk ve Hassasiyetlerinin Değerlendirilmesi

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ABSTRACT

Objectives: This study compared the trueness and precision of conventional alginate impressions (metal tray and custom tray) and a digital impression method in a Kennedy Class III partially edentulous model.

Materials and Methods: A reference model was obtained from a polyether impression and Type III stone cast and scanned to generate reference STL data. As a single-patient repeated-measures study thirty-six impressions were allocated to three groups (n=12): metal tray alginate, custom tray alginate, and digital intraoral scanning. Test STL files were superimposed onto the reference STL, and RMS deviations were calculated for the edentulous area, teeth, palate, and whole arch. Trueness was defined as deviation from the reference model, and precision as within-group repeatability. Data were analyzed using Welch ANOVA/Games-Howell or Kruskal-Wallis/Dunn tests (α=0.05).

Results: No significant difference in trueness was found for the edentulous area (P=0.077). Significant differences were observed for teeth (P<0.001), palate (P=0.029), and whole arch (P=0.011); the digital method showed the highest deviations for teeth and whole arch but the lowest for the palate. For precision, the digital method showed significantly lower deviations in the edentulous area (P=0.004), teeth (P<0.001), and palate (P=0.046), while no difference was found for the whole arch (P=0.172).

Conclusion: The digital method demonstrated trueness comparable to conventional techniques in the edentulous area and superior precision in most regions, supporting its use for Kennedy Class III removable prosthodontic applications despite reduced trueness in tooth-bearing and whole-arch regions.

Keywords: *Prosthodontics, Reproducibility of results, Three-dimensional imaging.*

ÖZET

Amaç: Bu çalışmanın amacı, Kennedy Sınıf III bir modelde konvansiyonel aljinat ölçü yöntemlerinin (prefabrik kaşık ve bireysel kaşık) ve dijital ölçü yönteminin doğruluk ve hassasiyetini karşılaştırmalı olarak değerlendirmektir.

Gereç ve Yöntemler: Referans model, polieter ölçü ve Tip III alçı kullanılarak elde edilmiş ve referans STL verisi oluşturmak amacıyla taranmıştır. Tek hastada ve tekrarlı ölçü alınan bu çalışmada otuz altı ölçü üç gruba ayrılmıştır (n=12): prefabrik kaşık ile aljinat ölçü, bireysel kaşık ile aljinat ölçü ve ağız içi tarayıcı ile dijital ölçü. Test STL verileri referans STL verisi ile çakıştırılmış ve dişsiz bölge, dişler, damak ve tüm ark için RMS sapmaları hesaplanmıştır. Doğruluk, referans modele göre sapma; hassasiyet ise grup içi tekrarlanabilirlik olarak tanımlanmıştır. Veriler Welch ANOVA/Games-Howell veya Kruskal-Wallis/Dunn testleri ile analiz edilmiştir (α=0,05).

Bulgular: Dişsiz bölgede doğruluk açısından anlamlı fark bulunmamıştır (P=0,077). Dişler (P<0,001), damak (P=0,029) ve tüm ark (P=0,011) için anlamlı farklılıklar saptanmıştır; dijital yöntem dişler ve tüm arkta en yüksek, damakta ise en düşük sapmayı göstermiştir. Hassasiyet açısından dijital yöntem dişsiz bölgede (P=0,004), dişlerde (P<0,001) ve damakta (P=0,046) anlamlı derecede daha düşük sapma göstermiş, tüm arkta ise anlamlı fark bulunmamıştır (P=0,172).

Sonuç: Dijital yöntem, dişsiz bölgede konvansiyonel yöntemlerle benzer doğruluk ve çoğu bölgede üstün hassasiyet göstermiştir. Bu bulgular, Kennedy Sınıf III hareketli protez vakalarında dijital ölçülerin kullanılabileceğini desteklemektedir. Ancak dişler bölgesinde ve tüm ark değerlendirmesinde gözlenen daha yüksek sapmalar, tarama ve görüntü birleştirme süreçlerinin genel doğruluğu sınırlayabileceğini düşündürmektedir.

Anahtar Kelimeler: *Protetik diş tedavisi, Sonuçların tekrarlanabilirliği, Üç boyutlu görüntüleme.*

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Introduction

The success of prosthetic treatment in dentistry depends on the biological, functional, and esthetic compatibility of the restorations. Accurate transfer of the form and function of intraoral tissues onto the working model is of major importance in achieving this compatibility. The impression procedure, at this stage of treatment, ensures detailed recording of the teeth and surrounding tissues, thereby influencing the accuracy of the restorations to be fabricated in the laboratory.[1-3]

Kennedy Class III partial edentulism is defined as a unilateral edentulous area bounded by natural abutment teeth on both sides and is planned as a tooth-supported restoration.[4-7] The biomechanical success of this design depends on the accurate recording of the position of the abutment teeth and the rest seats. An impression error may prevent the rests from fully seating in their preparations and may create undesirable lateral forces on the abutment teeth, thereby jeopardizing the long-term success of the prosthesis.

Among conventional impression materials, alginate is the most frequently preferred material owing to its ease of use and cost-effectiveness; however, it has disadvantages such as limited dimensional stability, syneresis, and technique sensitivity.[8,9] Polyether impression material, on the other hand, is regarded as the gold standard among conventional methods because of its high hydrophilicity, detail-reproduction capacity, and dimensional stability, and is frequently used as the reference impression in comparative studies.[8,10,11]

With the integration of digital technologies into dentistry in recent years, intraoral scanners have become increasingly common in clinical practice. Digital impression systems offer advantages such as elimination of material-related errors, increased patient comfort, and direct integration into the digital workflow.[12-14] Nevertheless, the accuracy performance of digital impressions in removable partial denture applications remains an actively investigated topic.

The aim of this study was to comparatively evaluate the trueness and precision values of conventional alginate impressions (prefabricated metal tray and custom tray) and a digital impression method in four different regions in a Kennedy Class III partially edentulous case.

The null hypothesis was that no significant differences would be found among the prefabricated metal tray alginate, custom tray alginate, and digital impression methods in terms of trueness and precision in the edentulous area, teeth, palate, and whole arch regions.

Materials and Methods

This clinical study was conducted at the Department of Prosthodontics, Faculty of Dentistry, Istanbul University; the study protocol was approved by the Istanbul University, Faculty of Dentistry Clinical Research Ethics Committee (ID number: 3902227 decision date: 03/02/2026). Informed consent was obtained from the volunteer patient. One volunteer was included in the study, who fulfilled the criteria of having a Kennedy Class III edentulous arch configuration, preserved periodontal health of the abutment teeth, and the absence of any pathological condition in the intraoral tissues that could affect impression accuracy. This dental arch is classified as Kennedy Class III, Modification 1, with tooth 16 forming a tooth-bounded edentulous space between teeth 15 and 17 on the right side, and teeth 23-26 forming a second tooth-bounded space between teeth 22 and 27 on the left side, with no free-end spaces present in the arch.

A custom impression tray was fabricated from chemically polymerized polymethyl methacrylate (PMMA) (SC Cold Cure Acrylic, Imicryl Dental, Konya, Türkiye) on a model produced from an impression taken with a prefabricated metal tray; the peripheral borders of the tray, the depth of the vestibular sulcus, and the frenum areas were clinically checked and adjusted as needed. The reference impression was obtained using a polyether material (Impregum, 3M ESPE, Seefeld, Germany) with the single-step technique and was poured in Type III dental stone to obtain the reference stone model. This model was scanned with a desktop laboratory scanner (3Shape E4, 3Shape, Copenhagen, Denmark) to generate the reference STL data.

A total of 36 test impressions were divided into the following three groups:

Group I – Prefabricated metal tray, alginate (n=12): An irreversible hydrocolloid material (Zhermack Tropicalgin, Zhermack, Italy) was used with an appropriately sized (No. 3) perforated prefabricated metal tray. The impressions were poured without delay in Type III dental stone (Type III Dental Stone, Cerestone, Turkey) to obtain stone models.

Group II – Custom tray, alginate (n=12): Custom impression trays were fabricated from PMMA on a preliminary model obtained with a prefabricated metal tray and alginate and were tried in clinically with the necessary adjustments. Twelve impressions were taken with the same alginate material and poured by the same method in Type III dental stone.

Group III – Digital impression (n=12): A standardized protocol was followed by the same operator using an intraoral scanner (Allied Star AS260E, Alliedstar Co, Shanghai, China) directly in the patient's mouth. The scanning sequence was as follows: occlusal surfaces first, followed by palatal, and finally buccal surfaces. Each scan was saved in STL format and transferred to the digital environment.

All test STL data were superimposed onto the reference STL using computer software (Geomagic Control X, 3D Systems, Rock Hill, SC, USA) by first applying an "Initial Alignment" and then a "Best-Fit Alignment" algorithm. Analyses were performed separately for four different anatomical regions: (1) whole arch (Figure 1A), (2) edentulous area (Figure 1B), (3) palate (Figure 1C), (4) teeth (Figure 1D). Deviation values for each region were calculated using the Root Mean Square (RMS) method. Trueness was defined as the mean deviation of each test group from the reference model, and precision was defined as the repeatability consistency within each group.[15]

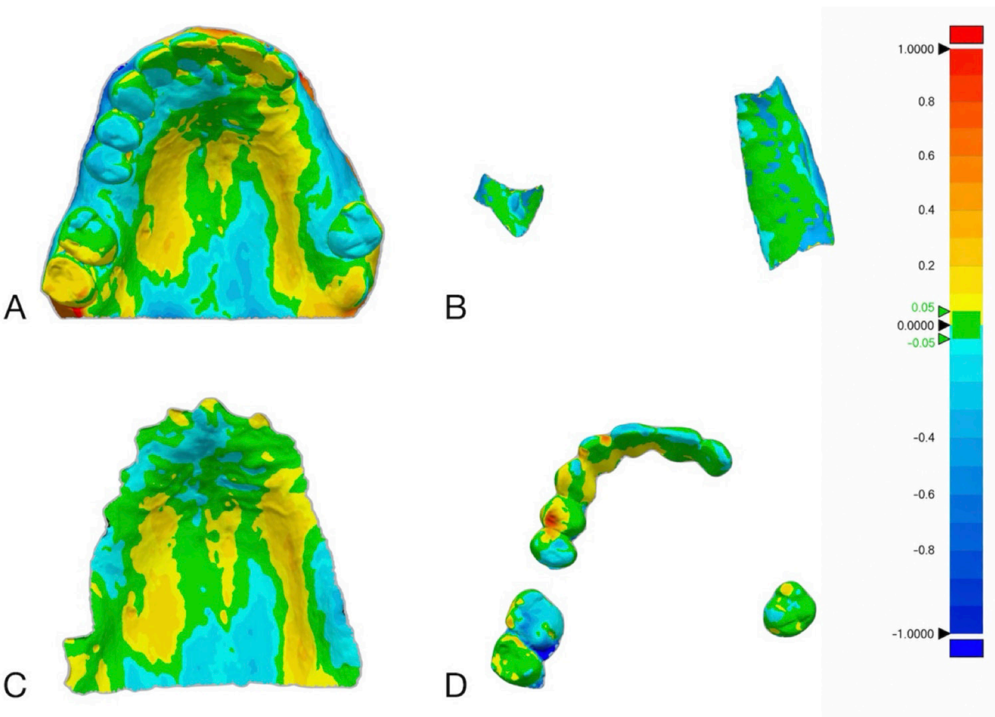

Figure 1. Regions selected for trueness and precision analyses. (A) Whole arch, (B) edentulous area, (C) palate, and (D) Teeth.

The adequacy of the sample size was evaluated using GPower software (GPower version 3.1.9.7; Heinrich Heine University Düsseldorf, Düsseldorf, Germany). The calculation was based on a medium effect size commonly used in repeated-measures method-comparison studies (Cohen's f = 0.25; equivalent to Cohen's d ≈ 0.5). A significance level of $\alpha = .05$, a statistical power of 80% ($1-\beta = 0.80$), and three impression methods (conventional impression with a prefabricated tray, conventional impression with a custom tray, and digital impression) were assumed. The G*Power analysis indicated that a minimum of 10 repeated measurements per group was required to reliably detect differences among the methods. Therefore, 12 repeated measurements were performed for each impression method. This sample size exceeded the minimum requirement in order to increase statistical power and better account for measurement variability.

The normality of data distribution was assessed with the Shapiro-Wilk test, and homogeneity of variances with the Levene test. For normally distributed data, Welch ANOVA and the Games-Howell post hoc test were used; for non-normally distributed data, the Kruskal-Wallis test with Bonferroni-corrected Dunn post hoc test was used. The level of statistical significance was set at $\alpha=0.05$ for all analyses.

Results

The regional trueness values of the different impression methods are presented in Table 1. A significant difference was found for the whole arch region (P=0.011) (Figure 2A). The digital impression showed the highest deviation (0.269±0.0113 mm). No statistically significant difference was found among the three methods for the edentulous area (P=0.077) (Figure 2B). The deviation values for Groups I, II, and III were 0.125±0.0496 mm, 0.108±0.0360 mm, and 0.0932±0.0112 mm, respectively. A significant difference was found among the methods for the palate region (P=0.029) (Figure 2C). The digital impression yielded the lowest deviation (0.246±0.0126 mm). A significant difference was found among the methods for the teeth region (P<0.001) (Figure 2D). The highest deviation was observed in Group III (0.183±0.00891 mm), and the digital method differed statistically significantly from the other two groups.

Table 1. Effect of different impression types on impression trueness

	Impression Type							
	Group I		Group II		Group III		Test Statistic	*P*
Region	mean±sd	median (min-max)	mean±sd	median (min-max)	mean±sd	median (min-max)		
Edentulous area	0.125 ± 0.0496	0.116 (0.0725–0.227)	0.108 ± 0.0360	0.0983 (0.0676–0.172)	0.0932 ± 0.0112	0.0955 (0.0748–0.105)	3.01	0.077
Teeth	0.174 ± 0.0750	0.159 (0.131–0.410)[b]	0.172 ± 0.0229	0.166 (0.149–0.234)[ab]	0.183 ± 0.00891	0.186 (0.164–0.193)[a]	14.72	<0.001
Palate	0.261 ± 0.0277	0.259 (0.218–0.308)[ab]	0.271 ± 0.0234	0.282 (0.241–0.310)[b]	0.246 ± 0.0126	0.244 (0.227–0.270)[a]	7.05	0.029
Whole Arch	0.258 ± 0.0433	0.251 (0.220–0.389)[b]	0.264 ± 0.0232	0.260 (0.239–0.313)[ab]	0.269 ± 0.0113	0.268 (0.256–0.298)[a]	8.96	0.011

[a-b]Groups sharing the same letter in the same row are not significantly different from each other.

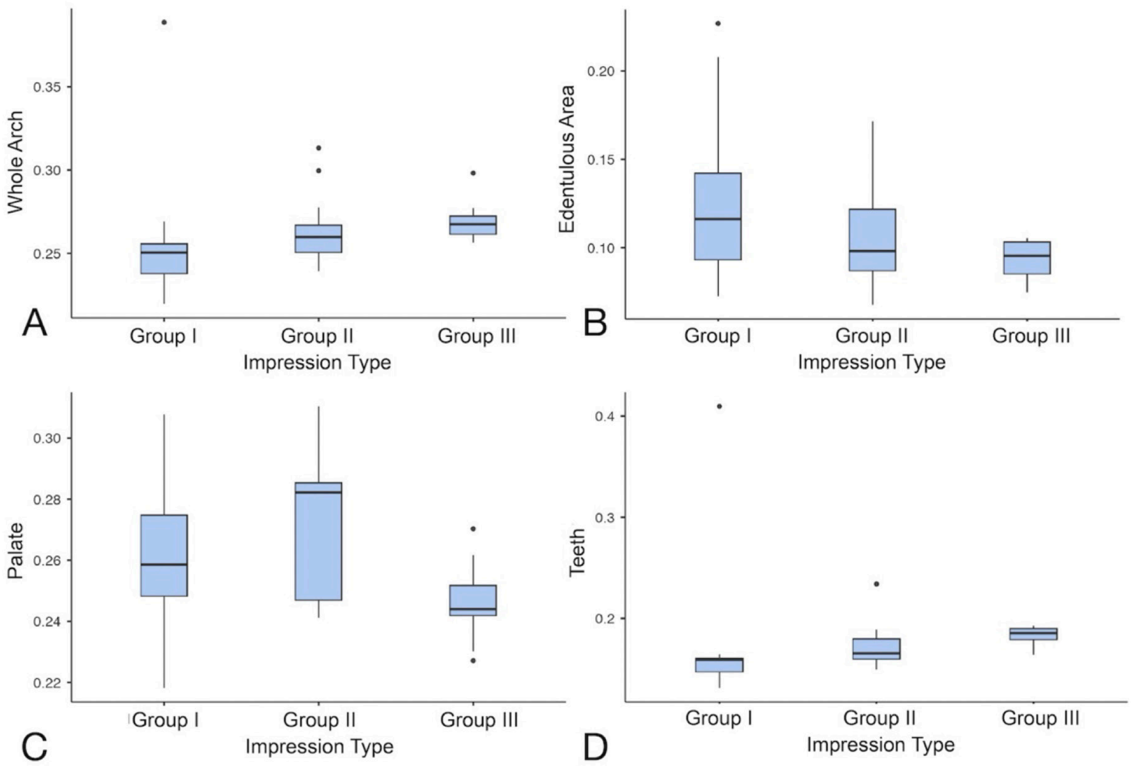

Figure 2. Trueness values of the different impression methods. (A) Whole arch, (B) edentulous area, (C) palate, and (D) teeth.

The precision values of the different impression methods are presented in Table 2. For the whole arch, although the deviation values of the digital impression were lower (0.008±0.008 mm), the difference among the methods was not significant (P=0.172) (Figure 3A). A significant difference was found among the groups for the edentulous area (P=0.004) (Figure 3B). The lowest deviation (highest precision) was observed in Group III (0.010±0.004 mm). A significant difference was found for the palate region (P=0.046) (Figure 3C). The digital impression showed a significantly lower deviation (0.009±0.008 mm). A significant difference was found among the methods for the teeth (P<0.001) (Figure 3D). Group III exhibited the highest precision (0.007±0.005 mm).

Table 2. Effect of different impression types on impression precision

	Impression Type							
	Group I		Group II		Group III		Test Statistic	*P*
Region	mean±sd	median (min-max)	mean±sd	median (min-max)	mean±sd	median (min-max)		
Edentulous area	0.037 ± 0.031[c]	0.023 (0.004–0.102)	0.028 ± 0.021[b]	0.026 (0.005–0.063)	0.010 ± 0.004[a]	0.010 (0.002–0.018)	8.13	0.004
Teeth	0.039 ± 0.063	0.020 (0.009–0.236)[b]	0.016 ± 0.016	0.012 (0.003–0.062)[ab]	0.007 ± 0.005	0.006 (0.001–0.019)[a]	15.02	<0.001
Palate	0.021 ± 0.017	0.014 (0.002–0.046)[ab]	0.021 ± 0.009	0.019 (0.011–0.040)[b]	0.009 ± 0.008	0.005 (0.001–0.024)[a]	6.15	0.046
Whole Arch	0.024 ± 0.035	0.013 (0.003–0.131)	0.017 ± 0.016	0.012 (0.000–0.050)	0.008 ± 0.008	0.007 (0.000–0.029)	3.52	0.172

[a-c]Groups sharing the same letter in the same row are not significantly different from each other.

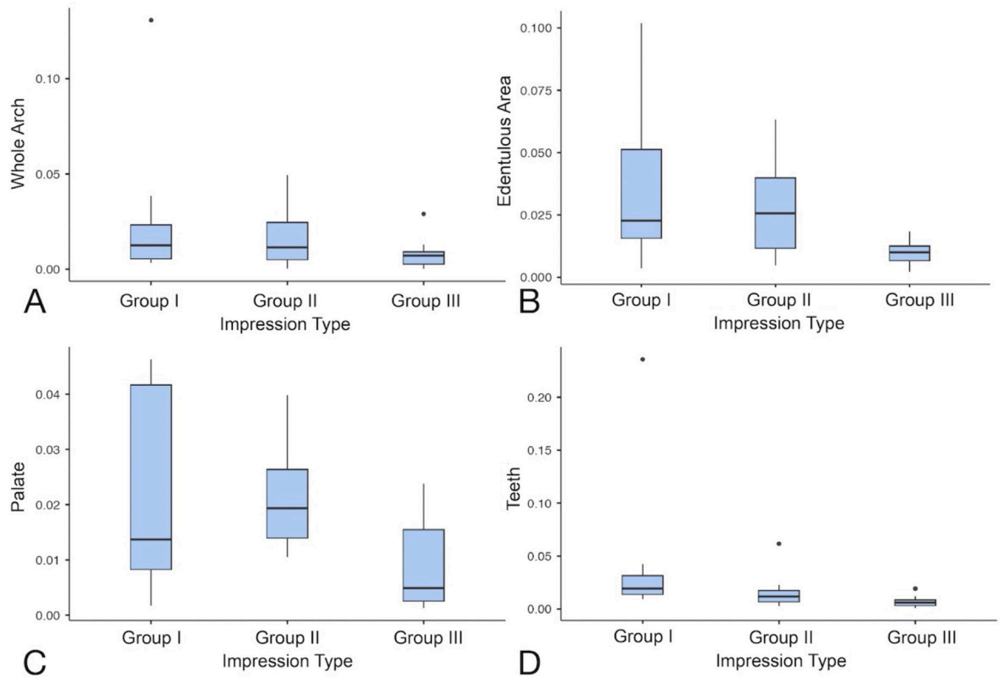

Figure 3. Precision values of the different impression methods. (A) Whole arch, (B) edentulous area, (C) palate, and (D) teeth.

Discussion

The null hypothesis was partially rejected, as significant differences among the impression methods were identified in several regions for both trueness and precision analyses.

The digital method exhibited high precision; however, it did not demonstrate the same superiority in terms of trueness in every region. In Kennedy Class III, the edentulous space is bounded by teeth on both sides; this may facilitate the image-stitching process during digital scanning, as the adjacent teeth provide additional anatomical references. Indeed, Hayama et al.[16] reported that digital impressions showed higher trueness compared with conventional impressions in the partially edentulous mandible. Diker and Tak[17], and Lee et al.[18], emphasized that the number of missing teeth, the length of the edentulous span, and the scanning strategy can affect the trueness of digital impressions, and that trueness may decrease in wider and more complex edentulous areas. In this context, the absence of a significant difference for the edentulous area in the present study suggests that digital and conventional methods may converge in a short and limited Kennedy Class III span.

The highest deviation in the teeth region was reported for the digital impression. This finding indicates that the digital dataset exhibits a consistent but lower trueness profile. The literature reports that scanning strategy, image stitching algorithm, and operator experience can affect trueness.[17,19,20] Therefore, the deviation observed in the tooth bearing regions cannot be explained by material differences alone; scanning strategy and software algorithms are also considered to play a determining role.

In the palate region, the digital impression yielded the most favorable results in terms of both trueness and precision. This may be explained by the elimination, in the digital workflow, of the cumulative error sources present in the conventional chain, such as material deformation, tray pressure, model pouring, and stone expansion. However, Frank et al.[21] showed that the trueness of the palatal vault in models obtained from irreversible hydrocolloid impressions depends not only on the tray type but also on the pouring steps. In addition, in the in vivo study by Yao et al.[22], the deviation of the palate region was found to be higher than that of the tooth bearing area. Therefore, the palatal superiority observed in the present study indicates that the digital method is advantageous in this specific anatomy and workflow, and a universal generalization should not be made.

In the whole arch trueness analysis, the digital method showed the highest mean deviation, whereas Group I showed the lowest value. This may be explained by the fact that the whole arch analysis evaluates the teeth, edentulous area, and palate as a single entity, which renders the cumulative errors of digital scanning more apparent.[17,18,23]

In terms of precision, the digital method yielded the lowest deviation in all regions, and this advantage reached statistical significance in the edentulous area, tooth, and palate regions. The elimination of the error margin arising from numerous variables in conventional methods—such as mixing the impression material, loading the tray, removal from the mouth, disinfection, and model pouring—explains the superior repeatability of the digital system. Indeed, Garrofé et al.[24] reported that time significantly affects the dimensional stability of irreversible hydrocolloid materials; this finding supports the wide distribution observed in repeated conventional impressions.

The findings of Schimmel et al.[20] and Alfaraj et al.[23] demonstrated that precision is highly dependent on the scanner used and the clinical scenario. Therefore, the precision data of the present study reflect only the repeatability obtained in this specific digital workflow and in this Kennedy Class III case.

From a clinical perspective, these data indicate that the digital approach is a strong candidate, particularly in terms of precision, for Kennedy Class III removable partial denture cases. The fact that the trueness of the edentulous area was comparable with conventional methods, together with the marked precision advantage in the edentulous area and palate region, supports the applicability of digital impressions in such cases.[16,20,22]

The main limitation of this study is that it was based on a repeated-measures design performed in a single patient. Therefore, the precision results obtained reflect repeatability within the same patient, whereas the trueness results reflect proximity to the reference model in this specific anatomy. Since the study represents only a single Kennedy Class III scenario, the findings cannot be generalized to different span lengths, palatal anatomies, scanner systems, or operators.

Conclusion

In this clinical study, comparing conventional and digital impression methods in a Kennedy Class III partially edentulous case, the following conclusions were reached:

1. In terms of edentulous-area trueness, the intraoral scanner exhibited a performance comparable to the conventional alginate methods; this finding indicates that digital systems can successfully record the morphology of the edentulous region in Kennedy Class III cases.

2. The digital impression exhibited statistically significantly higher precision than the conventional methods in the edentulous area, tooth, and palate regions. The minimization of operator- and material-related error sources explains this superiority of the digital system.

3. In the tooth region and over the whole arch surface, digital scanning showed higher deviation values compared with the polyether reference impression. This finding indicates that image-stitching errors in long-arch scans can adversely affect trueness.

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Ethical Approval

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Conflict of Interest

The authors declare no conflicts of interest regarding the subject matter or materials discussed in this article.

Authorship Contributions

Idea/Concept: S.S Design: S.S Control/ Supervision: S.S, T.S Materials: D.P, S.S, Data Collection and/ or Processing: D.P, A.A Literature Review: D.P, A.A Analysis and/or Interpretation: D.P, A.A Writing the Article: D.P, A.A Critical Review: S.S, T.S

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